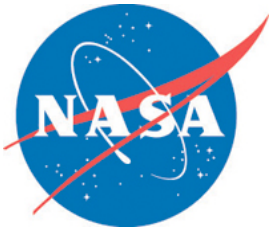

MSFC Systems Engineering Development Process
Version 1.0

Systems Management Office
Employee and Organizational Development Department

October 2004

MSFC Systems Engineering Development Process Version 1

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Steve Newton
Safety and Mission Assurance Directorate
Systems Management Office
Marshall Space Flight Center

Jerry Miller
Customer and Employee Relations Directorate
Employee and Organizational Development Department
Marshall Space Flight Center

Introduction

The Marshall Space Flight Center (MSFC) Systems Engineering (SE) Development Process (SEDP) Implementation Guide helps employees, who are interested in developing as a Systems Engineer for flight hardware/software projects, plan their careers with NASA. This guide describes the work experiences expected for each of the four SE Certification Levels, describes the required training for each level, and has a checklist that describes how to apply for the appropriate certification level.

There are four SE Certification Levels:

1. Level I—Technical Engineer/Project Team Member: Employees applying for Level I Certification will have obtained a working knowledge of technical integration and systems engineering concepts and tools. They will have contributed to project activities and performed tasks to support a project. The emphasis on Level I candidates is knowledge and understanding of technical integration, SE and basic project management.

2. Level II—Subsystem or Small Project Systems Engineer: Employees applying for Level II Certification will have had sufficient experience and responsibility required, preparing them to lead SE and technical integration activities on a subsystem or small project. They will have been responsible for or led activities such as requirements development, system analysis, trade studies, technical integration, design, development, or test and evaluation. They will also have been responsible for technical inputs to program planning activities and risk management. The emphasis on Level II candidates is leadership application and participation in SE.

3. Level III—Major System or Project Systems Engineer: Employees applying for Level III Certification will have taken a significant leadership role in SE. They will have experience in multiple phases of a project life cycle managing all technical integration and SE functions for a subsystem or small project that would prepare the employee for a technical leadership role in support of a major system or project. The emphasis on Level III candidates is the directing, structuring, and integration activities of SE.

4. Level IV—Program or Large Project Systems Engineer: Employees applying for Level IV Certification will have demonstrated superior competencies in aspects of formulation and implementation SE activities associated with a major system or project that would prepare the employee for greater SE responsibilities associated with a program or large project. They will have contributed to Agency goals and been effective in managing technical and strategic interfaces both internal and external to the Agency. The emphasis on Level IV candidates is the strategy for SE of large complex initiatives.

The SEDP Certification process places a strong emphasis on work experience supported by appropriate training and education. Successful candidates have found that a breadth of technical and managerial experiences, supplemented with appropriate rotational assignments, provides a solid basis for addressing the required competencies. Candidates are evaluated on their portfolio-application package, training, Individual Development Plans (IDPs), and work history.

Descriptions of required SEDP courses are included in this guide. Candidates are expected to have completed all required courses for their requested level of certification as well as the courses for lower levels. A candidate may request a waiver of a course if they have evidence that they have mastered the course objectives by alternative training, work experience, or both. The candidate may submit a waiver justification of no more than 2 pages for consideration by the Project Management Board (PMB).

This guide includes a complete listing of the competency expectations obtained from work experiences for each level and a list of training expectations. A checklist is also included that describes the steps in the certification process. Employees interested in applying for SE Certification should contact the SEDP Coordinator in the SMO or Employee and Organization Development Department (EODD) and consult the EODD SEDP Web site at http://mi.msfc.nasa.gov/sedp/index.shtml. The SEDP Coordinators will be able to answer questions on the SEDP. The SEDP Web site will provide application templates, frequently asked questions, additional recommended training courses, and a link to the electronic Certification (eCert) Web site. The eCert Web site will allow the candidates to securely upload completed applications for tracking and review.

Certification Checklist for Systems Engineering Development Process

Activity	Applicant	SEDP Coordinator	PMB
1.0 Prepare the application for certification in SEDP			
1.1 Contacting the SEDP Coordinator The SEDP Coordinator can provide current information on the SEDP and give guidance in selecting the appropriate certification level.	√		
1.2 Completion of the application The application template for each level can be downloaded and completed electronically from the SEDP Web site: http://mi.msfc.nasa.gov/sedp/index.shtml. Follow the checklist provided in Part 1 of the application.	√		
1.3 Application submittal The candidate will need to submit a hardcopy to the EODD SEDP Coordinator and upload an electronic copy of the application to the eCert Web site, which is accessed through the SEDP Web site.	√		
2.0 Project Management Development Process Coordinator			
2.1 Application review The SEDP Coordinators in the SMO and the EODD will review the application.		√	
2.2 PMB Agenda The application will be added to the agenda for a PMB Meeting; Levels II, III, and IV candidates will be contacted to schedule their oral briefing to the PMB.		√	
2.3 Distribute application An agenda and all applications are distributed to the PMB members no later than 3 days before the meeting.		√	
3.0 Project Management Board			
3.1 Application Review PMB members will have the opportunity to review applications prior to the PMB meeting.			√
3.2 PMB certification meeting At the meeting, the PMB will review the application, the accomplishments briefing, and the collective knowledge of the candidate. The PMB may recommend to MSFC Center Management the requested level of certification, a lower level of certification, or may decline to recommend certification.			√
3.3 Notification Candidates will be contacted after the PMB Meeting.			√

General Systems Engineering Development Process Level Descriptions/Definitions

(Note: Each Directorate/Office will classify the level of each of the programs, projects, and activities (PPA) within their organization. Key project personnel must be certified to the designated level of the PPA that they are supporting. Please refer to the EODD Web page, http://mi.msfc.nasa.gov/sedp/index.shtml, for certification application templates.)

(Note: Level I knowledge and understanding may be obtained via formal training courses, self-study, applicable work experience, etc. The application and adaptation of the knowledge required for Levels II, III, and IV can only be validated by successful accomplishments in support of a program or project.)

	Level			
	I	**II**	**III**	**IV**
Levels of Project Leadership	**Technical Engineer/ Project Team Member**	**Subsystem or Small Project Systems Engineer**	**Major System or Project Systems Engineer**	**Program or Large Project Systems Engineer**
Description	Performs fundamental and routine activities, while supporting a systems engineer as a member of a project team.	Performs SE of a simple project (e.g., no more than one or two simple internal/external interfaces, smaller team, simpler contracting processes, smaller budget, shorter duration, etc.) or subsystem to a larger system effort.	Performs SE of a more complex project (multiple distinct subsystems/ parts/pieces, or other defined services, capabilities, or products) with associated interfaces.	Performs SE of a complex program or a very large complex project with multiple associated interfaces.
Key Words	knowledge, understanding	application, participant	direct, structuring, integrating	manage, strategy
Required Courses	Foundations of Project Management, Systems Engineering	Systems Requirements; Trade Studies; Verification, Validation and Test; Continuous Risk Management	Lessons Learned, System Safety Fundamentals, COTR, Advanced Systems Engineering and Integration	

Competency Worksheet Requirements

Competency Title	Level I	Level II	Level III	Level IV
1.0 Program/ Project Conceptualization & Planning				
1.1 Project Concept Definition	Understanding of requirements analysis, functional analysis, synthesis, trading and selecting architectures and concepts including technologies. Understanding of sensitivity, uncertainty, and margin analysis in decision making, balancing the system among performance, cost, schedule, reliability, and operability.	Participated in requirements analysis, functional analysis, synthesis, trading and selecting architectures and concepts including technologies. Participated in sensitivity, uncertainty, and margin analysis in decision making, balancing the system among performance, cost, schedule, reliability, and operability.	Demonstrated capability in requirements analysis, functional analysis, synthesis, trading and selecting architectures and concepts including technologies. Demonstrated capability in sensitivity, uncertainty, and margin analysis in decision making, balancing the system among performance, cost, schedule, reliability, and operability.	Directed requirements analysis, functional analysis, synthesis, trading and selecting architectures and concepts including technologies. Directed sensitivity, uncertainty, and margin analysis in decision making, balancing the system among performance, cost, schedule, reliability, and operability.
1.2 Technical Integration	Understanding of the principles and planning (activities and resources) for technical integration of project elements, design functions, discipline functions, and their associated interfaces and interactions to ensure a balanced and compatible system throughout the life cycle.	Participated in the application of principles and planning (activities and resources) for technical integration of project elements, design functions, discipline functions, and their associated interfaces and interactions to ensure a balanced and compatible system throughout the life cycle.	Demonstrated capability in the application of principles and planning (activities and resources) for technical integration of project elements, design functions, discipline functions, and their associated interfaces and interactions to ensure a balanced and compatible system throughout the life cycle.	Directed the application of principles and planning (activities and resources) for technical integration of project elements, design functions, discipline functions, and their associated interfaces and interactions to ensure a balanced and compatible system throughout the life cycle.

Competency Title	Level I	Level II	Level III	Level IV
1.3 Requirements Development	Understanding of the process of development and iteration of technical requirements, including stakeholder acceptance. This includes analyzing and challenging impacts, capturing relevant standards and criteria, and ensuring each requirement is verifiable. Knowledge of requirements baselining, traceability, change process, and allocation.	Contributed to development and iteration of technical requirements, including stakeholder acceptance. This includes analyzing and challenging impacts, capturing relevant standards and criteria, and ensuring each requirement is verifiable. Participated in requirements baselining, traceability, change process, and allocation.	Led development and iteration of technical requirements for a small project, subsystem, or equivalent entity, including stakeholder acceptance. This includes analyzing and challenging impacts, capturing relevant standards and criteria, and ensuring each requirement is verifiable. Demonstrated capability in requirements baselining, traceability, change process, and allocation.	Managed development and iteration of technical requirements for a large project, major system, or equivalent entity, including stakeholder acceptance. This includes analyzing and challenging impacts, capturing relevant standards and criteria, and ensuring each requirement is verifiable. Directed requirements baselining, traceability, change process, and allocation.
1.4 Project Planning	**A)** Knowledge of life cycle project planning as related to Work Breakdown Structure (WBS), budget, schedule, staffing, configuration and data management, technical reviews, and project success criteria.	**A)** Participated in development of technical inputs for project life cycle plan, as related to WBS, budget, schedule, staffing, configuration and data management, technical reviews, and project success criteria.	**A)** Developed technical inputs for project life cycle plan, as related to WBS, budget, schedule, staffing, configuration and data management, technical reviews, and project success criteria.	**A)** Directed development of technical inputs for project life cycle plan, as related to WBS, budget, schedule, staffing, configuration and data management, technical reviews, and project success criteria.
	B) Knowledge of project formulation activities.	**B)** Participated in project formulation activities.	**B)** Technical lead on a small project, subsystem, or equivalent entity during formulation phase with authority for technical decisions.	**B)** Managed technical aspects of a large project, major system, or equivalent entity during formulation phase with authority for technical decisions.

Competency Title	Level I	Level II	Level III	Level IV
1.5 Acquisition Strategies, Procurement and Contracting	Awareness of development of contract statements of work, data requirement descriptions (DRDs), technical metrics, and acceptance requirements to support flight hardware/software.	Contributed to the development of technical inputs for acquisition strategies and contract implementation, including technical metrics and DRDs.	Demonstrated capability in development of technical inputs for acquisition strategies and contract implementation, including technical metrics and DRDs.	Directed development of technical inputs for acquisition strategies and contract implementation, including technical metrics and DRDs.

Competency Title	Level I	Level II	Level III	Level IV
2.0 Continuous Risk Management				
2.1 Risk Management	Understanding of risk management process, integrating discipline inputs and utilizing technical risk analysis and associated mitigation to support decision making.	Participated in a risk management process, integrating discipline inputs and utilizing technical risk analysis and associated mitigation to support decision making.	Led a risk management process, integrating discipline inputs and utilizing technical risk analysis and associated mitigation to support decision making.	Directed a risk management process, integrating discipline inputs and utilizing technical risk analysis and associated mitigation to support decision making.
2.2 Technical Insight	Awareness of risk-based technical penetration/insight required for contractor activities.	Supported development of risk-based technical penetration/insight required for contractor activities and decision making.	Demonstrated capability in developing risk-based technical penetration/insight required for contractor activities and decision making.	Responsible for developing risk-based technical penetration/insight required for contractor activities and decision making.

Competency Title	Level I	Level II	Level III	Level IV
3.0 Budget Management				
3.1 Project Budget	Understanding of the project budget development process and balancing of cost, schedule, and technical aspects of the project.	Provided technical inputs and identified associated cost drivers for project budget development process.	Led activity to provide technical inputs and identified associated cost drivers for budget development and iterations for a small project, subsystem, or equivalent entity.	Managed technical aspects and identified associated cost drivers for budget development and iterations for a large project, major system, or equivalent entity.

Competency Title	Level I	Level II	Level III	Level IV
4.0 Project Implementation				
4.1 Systems Engineering and Technical Integration	Knowledge of NASA and MSFC SE directives. Understanding of project/technical integration of project elements, design functions, discipline functions, and associated interfaces and interactions.	Applied NASA and MSFC SE directives. Participated in technical integration of project elements, design functions, discipline functions, and associated interfaces and interactions.	Leadership in structuring and implementing technical activities to conform to NASA and MSFC SE directives. Leadership in technical integration of project elements, design functions, discipline functions, and associated interfaces and interactions, making technical decisions to balance performance, cost, schedule, reliability, and operability.	Directed technical activities to conform to NASA and MSFC SE directives. Management of technical integration of project elements, design functions, discipline functions, and associated interfaces and interactions, making technical decisions to balance performance, cost, schedule, reliability, and operability.
4.2 Design, Development, Test, and Evaluation	Understanding of the project implementation process, including design, develop-ment, test, and evaluation of-flight hardware/software.	Participated in the design, development, test, and evaluation of-flight hardware/software.	Technical leader on a small project, subsystem, or equivalent entity during implementation phase, including design, develop-ment, test, and evaluation of flight hardware/software, with authority for technical decisions.	Managed the technical aspects of a large project, major system, or equivalent entity during implementation phase, including design, development, test, and evaluation of-flight hardware/software, with authority for technical decisions.

Competency Title	Level I	Level II	Level III	Level IV
4.3 Operations	Knowledge of planning and execution of flight hardware/software training, logistics, ground operations, launch and mission operations, flight data, and retirement for a subsystem or small project.	Contributed to planning and execution of flight hardware/software training, logistics, ground operations, launch and mission operations, flight data, and retirement for a subsystem or small project.	Provided technical leadership for the planning and execution of flight hardware/software training, logistics, ground operations, launch and mission operations, flight data, and retirement for a small project, subsystem, or equivalent entity. Integrated these factors into the design. Responsible for technical decisions made during operations to ensure project/ mission success.	Managed the technical aspects of planning and execution of flight hardware/software training, logistics, ground operations, launch and mission operations, flight data, and retirement for a large project, major system, or equivalent entity. Integrated these factors into the design. Responsible for technical decisions made during operations to ensure project/ mission success.
4.4 Stakeholder Management	Awareness of stakeholder involvement and communication. Awareness of political, economic, and other factors that influence project goals.	Contributed to developing and maintaining stakeholder communication and assessing both internal and external influences on the project.	Demonstrated capability to include stakeholders and assess both internal and external influences throughout the project life cycle.	Directed technical aspects of developing and maintaining stakeholder communication throughout the project life cycle, assessing both internal and external influences on the project.

Competency Title	Level I	Level II	Level III	Level IV
5.0 Program/Project Management and Control				
5.1 Contract Management	Understanding of contract change control process.	Experience with contract change control.	Demonstrated capability to provide technical inputs for project contract management, including change control.	Developed technical rationale and risk for contract change control board.
5.2 Project Monitoring and Control	Understanding of project tracking, reporting, and evaluation of technical performance metrics. Understanding of risk and technical reserve analysis. Attended technical monitoring and formal reviews.	Contributed to project tracking, reporting, and evaluation of technical performance metrics. Participated in risk analysis and technical reserve analysis. Participated in technical monitoring and formal reviews.	Leadership role in project tracking, reporting, and evaluation of technical performance metrics. Utilized earned value analysis, risk analysis, and technical reserve management. Leadership in developing, evaluating, and implementing mitigation efforts to address performance variances. Utilized continual technical monitoring and formal reviews.	Managed project tracking, reporting, and evaluation of technical performance metrics. Utilized performance metrics, earned value and risk analysis, and technical reserve management. Managed the development, evaluation, and implementation of mitigation efforts to address performance variances. Conducted continual technical monitoring and formal reviews.

Competency Title	Level I	Level II	Level III	Level IV
6.0 Safety and Mission Assurance				
6.1 Mission Assurance	Knowledge of project activities to support safety and mission assurance, including project quality and safety management, and the Certificate of Flight Readiness (CoFR) process.	Experience with project activities to support safety and mission assurance such as involvement with flight safety reviews and quality or safety plans, hazards assessments, failure modes and effects analysis, fault trees, and safety verification data. Contributed to the CoFR process.	Technical leadership role supporting safety and mission assurance through activities such as flight safety reviews and approval of quality or safety plans, hazards assessments, failure modes and effects analysis, fault trees, and safety verification data. Supported a project through the CoFR process.	Managed technical aspects of a project to ensure safety and mission assurance procedures were employed, including flight safety reviews, quality and safety plans, hazards assessments, failure modes and effects analysis, fault trees, and safety verification data. Managed technical aspects of the CoFR process.

Competency Title	Level I	Level II	Level III	Level IV
7.0 NASA and External Environment				
7.1 Agency Structure, Mission, and Internal Goals	Understanding of Center's roles and relationships. Understanding of Agency/Center vision, mission, plans, and objectives.	Contributed to activities addressing alignment and metrics of assigned functions with Agency vision, mission, plans, and objectives.	Participated in actively addressing alignment and metrics of assigned functions with Agency vision, mission, plans, and objectives.	Leadership in actively addressing alignment and metrics of assigned functions with Agency vision, mission, plans, and objectives.
7.2 NASA PM/SE Procedures and Guidelines	Knowledge of NASA and MSFC Project Management (PM) and SE directives.	Application of NASA and MSFC PM and SE directives.	Experience in structuring technical activities to conform to NASA and MSFC PM and SE directives.	Experience in establishing technical policy directives and criteria for conformation to NASA and MSFC PM and SE directives.

Competency Title	Level I	Level II	Level III	Level IV
7.3 External Relationships	Knowledge of activities involving multiple organizations outside the Center, requiring a network of external contacts, including industry partners and utilization of the NASA infrastructure.	Contributed to activities involving multiple organizations outside the Center, developing a network of external contacts, including industry partners and utilization of the NASA infrastructure.	Major participation in activities involving multiple organizations-outside the Center, enabled by a network of external contacts, including industry partners and utilization of the NASA infrastructure.	Leadership in development of partnerships, domestic and/ or international, and utilization of the NASA infrastructure.
7.4 ITAR and IT Security	Knowledge of International Traffic in Arms Regulations (ITAR) and information technology (IT) security requirements.	Applied ITAR and IT security requirements to technical information.	Managed technical information to comply with ITAR and IT security requirements for a small project, subsystem, or equivalent entity.	Managed technical information to comply with ITAR and IT security requirements for a large project, major system, or equivalent entity.

Competency Title	Level I	Level II	Level III	Level IV
8.0 Human Capital Management				
8.1 Staffing and Performance	**A)** Understanding NASA's processes for recruiting, evaluating, selecting, and staffing teams.	**A)** Involved in identifying and obtaining the required technical personnel resources and maintaining their skills for successful project formulation and implementation.	**A)** Demonstrated capability in identifying and obtaining the required technical personnel resources and maintaining their skills for successful project formulation, implementation, or operations.	**A)** Led establishment of staffing strategies for recruiting, evaluating, selecting, and maintaining skills of project technical personnel.
	B) Basic understanding of techniques for motivating and rewarding professional performance.	**B)** Participated in achieving desired performance through other personnel.	**B)** Demonstrated achievement of desired performance through leadership of a technical team.	**B)** Demonstrated achievement of desired performance through leadership of multiple technical teams. Experience as supervisor desirable but not essential.
8.2 Team Dynamics and Management	Understands the importance of teamwork and was a member of a team. Awareness of advocacy and inquiry (openness to changing own viewpoint) to achieve team success. Understands principles of group dynamics.	Led a small team. Involved in team building. Applied advocacy/inquiry (openness to changing own viewpoint) within team. Demonstrated conflict resolution or problem solving within team.	Successfully led a technical team. Promoted advocacy/inquiry (openness to changing own viewpoint) within team. Demonstrated decision making, conflict resolution, and problem solving within or among teams.	Successfully led a major technical team. Accomplished the application of advocacy/inquiry (openness to changing own viewpoint) within team. Demonstrated decision making, conflict resolution, and problem solving within or among teams.

Competency Title	Level I	Level II	Level III	Level IV
9.0 Professional and Leadership Development				
9.1 Mentoring and Coaching	Understands the importance of coaching and mentoring.	Coached and mentored subordinates or persons from other groups. Received periodic personal coaching from an administrative coach or mentor to improve identified weaknesses.	Provided opportunities for development of support personnel. Coached and mentored subordinates or persons from other groups. Received periodic personal coaching from an administrative coach or mentor to improve identified weaknesses.	Created a culture of development for support personnel. Established a coaching and mentoring climate and program for organization. Received periodic personal coaching from an administrative coach or mentor to improve identified weaknesses.
9.2 Communication	Developing skills in speaking, writing, and dialogue in formal and informal communications.	Experience in speaking, writing, and dialogue, both formally and informally. Made presentations of status, challenges and/or problem solutions.	Demonstrated skills in speaking, writing, and dialogue, both formally and informally. Made presentations to senior management, at professional meetings, or at public media events in support of NASA.	Demonstrated skills in speaking, writing, and dialogue, both formally and informally. Communicated and advocated to high levels of Government and public media regarding issues of importance to NASA and the public.
9.3 Leadership	Understands the need for leadership improvement and personal development activities.	Participated in leadership improvement and personal and professional development activities.	Demonstrated leadership improvement in personal and professional development activities.	Proactive in leadership improvement and personal development activities. Active participation in leadership assessments by team members throughout the project life cycle.

Competency Title	Level I	Level II	Level III	Level IV
10.0 Knowledge Management				
10.1 Knowledge Capture and Transfer	Understands the value of knowledge capture from all phases of a project, as well as application of lessons learned/best practices from previous programs and projects and significant studies, such as the *Columbia* Accident Investigation Board (CAIB) and Diaz Reports.	Contributed to the documentation of project history and lessons learned. Evaluated lessons learned/best practices from previous programs and projects and significant studies, such as the CAIB and Diaz Reports.	Integrated the documentation of project history and lessons learned. Demonstrated capabilities in the use of pertinent lessons learned/best practices from prior programs/projects and significant studies, such as the CAIB and Diaz Reports.	Managed the documentation of project history and lessons learned. Leadership in creating a lessons learned/best practices culture, drawing from previous programs/projects and significant studies, such as the CAIB and Diaz Reports.

Applicable Documents

The following documents are applicable to the SEDP process. NPR 7120.5 contains reference to the NASA Policy Directives and the NASA Procedures and Requirements that govern the various program/project management tasks.

NASA Documents

Number	Title
NPR 7120.5	NASA Program and Project Management Processes and Requirements
SP–6105	NASA Systems Engineering Handbook

Reference Documents

The following reference documents provide MSFC Procedures and Requirements and Work Instructions that govern the various program/project management tasks specifically at MSFC.

MSFC Documents

Number	Title
MPR 7100.1	Proposal Development Process
MPR 7120.1	Program/Project Planning
MPR 7120.4	MSFC Project Management Committee Process
MPR 8060.1	Flight Systems Design/Development Control
MWI 8050.1	Verification of Hardware, Software, and Ground Support Equipment for MSFC Projects
MWI 8060.3	Requirements and Design Reviews, MSFC Programs/Projects
MSFC–HDBK–3173	Program Management/Systems Engineering Handbook

Core Course Descriptions

Foundations of Project Management – Level I
Program Overview: NASA introduces the concepts, processes, and tools of PM to new team members in a fast-paced course that gives an overview of the Agency's project development process. Foundations of Project Management (FPM) is the Academy of Program/Project Leadership's (APPL's) introductory course for NASA's Level 1 managers or anyone who works with a project who wants to better understand PM skills and processes. The Foundations course also serves as the first step for any team member with the long-term career goal of becoming a project manager.

The course takes students beyond the technical fields in which they have trained and challenges them to understand how the project team functions as a whole. While working in an active, hands-on format, students learn the techniques, terms, and guidelines that are used to manage cost, schedule, risk, group dynamics, and technical aspects through the life cycle of a project, as described in the NASA Program and Project Procedures and Requirements document.

Presented as a combination of lecture, group work, and facilitated discussions, the curriculum promotes active learning. Working in small teams, students are challenged by a sequence of project activities as they absorb skills and lessons embedded in the course. As part of APPL's blended learning process, the FPM course introduces students to other Academy initiatives such as ASK Magazine, knowledge sharing workshops, and the continuing role that APPL will play in their professional careers at NASA.

This 4-day course is offered on demand at Centers throughout NASA. Students sign up through the NASA Online Registration System (NORS).

Representative outcomes include learning about:

- Project life cycle phases.
- Individual and team roles.
- WBS.
- Planning and scheduling.
- Reviews and success criteria.
- Risk management.
- Project safety.
- Earned value/performance indicators.
- Configuration management.
- Requirements.
- Prescribing documents.
- Acquisition management.

Systems Engineering – Level I
Program Overview: This course is a review of the latest principles for SE in context of NASA's project life cycle, with realistic practice on how to apply them. Systems Engineering is responsible for ensuring a development of a system that meets all requirements and provides the proper balance of quality, performance, cost, schedule, risk, and customer and user satisfaction. In this course, the attendee will learn the latest systems principles, processes, products and methods.

This course is offered on demand at MSFC. This 4-day course will cover the following topics:

- SE model.
- System requirements development.
- System architecture development.
- System integration and verification/validation.
- Operation and maintenance.
- Reviews and risk management.
- SE management.

Systems Requirements – Level II
Program Overview: This course defines the steps of a good requirements writing process; details the differences between good and bad requirements; how to avoid problems later in the life cycle process; and how to organize requirements into a specification. Best practices for systems specification, as documented by the leaders in systems, are presented. Major areas addressed include eliciting requirements from stakeholders; organization, analysis, and prototyping; recording and management; and preparing the specification text. Emphasis is given to management of the requirements team and using a goal-centered approach rather than a technology-centered, time-sequential approach. Data and techniques required to insure full life cycle management of requirements is provided and applied in lectures and hands-on exercises.

This 3-day hands-on workshop features lectures and exercises, and reviews of participants' own projects and products including discussion of solutions to existing problems. This course is offered at various Centers through the NASA Engineering Training (NET) program.

Trade Studies – Level II
Program Overview: The objective of the trade studies course is to provide a discipline and system engineers with both an overall paradigm and set of tools to structure problems related to complex systems design. Trade study techniques will enable the engineer to represent real-world design problems using models that can be analyzed to gain insight and understanding.

Trade studies are built on solid modeling techniques, and that is the focus of this course. Emphasis is placed on understanding the overall structure of design problems, accurate modeling of the problems, and gaining insight and understanding of the problem so appropriate decisions can be made. Good design decisions involve both analytical procedures and subjective assessments. The tools presented incorporate both the analytical and subjective data inputs so that sound engineering decisions can be made.

The course requires a significant level of student involvement. Topics are presented and students are tasked to demonstrate understanding by developing and executing models. A case study approach is used to relate trade study topics to real-world applications.

This course will be offered on demand at MSFC. This 4-day course covers the following topics:

- The trade study process.
- Structuring a trade study.
- Making decisions.
- Sensitivity analysis.
- The value of information.
- Modeling uncertainty.
- Modeling risk.
- Use of decision trees and influence diagrams.

Verification, Validation, and Test – Level II

Program Overview: An introduction and overview of Verification, Validation, and Test (VV&T) is provided including concepts, terminology and requirements; regulatory aspects; and documentation requirements. Failure analysis is addressed in depth, including the causes of failures in computer-based systems and hardware, software, and system failures. Test attributes of a successful testing program and the issue of risk identification and management as it relates to VV&T are also discussed. Participants join in a review and discussion of various VV&T techniques and the stages of the life cycle in which they can most ffecttively be applied. Case studies provide real-life examples of techniques and their application.

This 5-day workshop uses lectures, case studies, and class discussions. This course is offered at various Centers through the NET program.

Continuous Risk Management Principles and Practice – Level II

Program Overview: This 2-day course familiarizes the student with the fundamentals of Continuous Risk Management (CRM) and provides for interactive learning through the use of various methods and tools and a hypothetical space flight project case study. The second day is dedicated to organization-specific activities that will: 1) establish an organization-specific risk baseline; 2) practice the functions of the CRM paradigm; 3) promote teambuilding in a more cohesive work environment; 4) provide risk information that can be acted on immediately upon completion of the course. Emphasis can be placed on the creation of a Risk Management Plan as deemed necessary by each organization.

This 2-day course is offered on demand at MSFC. The course covers:

- How to identify risks in a specific format.
- To analyze risk probability, impact, and timeframe.
- Various plan approaches.
- To track risks through data compilation and analysis.
- Methods to control and monitor risks.
- To communicate and document the process and decisions.
- Methods and tools for supporting CRM activities.
- How to implement CRM within an organization.
- How to tailor the CRM process for your organization.

Lessons Learned – Level III
Program Overview: Preparation for the future of aerospace starts with visions of what it should be. Success of the endeavors will depend to a large extent, on the lessons we have learned from the past and present programs. This workshop is based on 48 years of aerospace experience consisting of Redstone, Jupiter, Saturn I, IB, and V (Apollo), Space Shuttle, X–33, HEAO, Skylab, Hubble, Chandra, Spacelab, etc. Presentations will be made of the lessons, derived by the instructors, from their experience working these projects. Typical lessons range from "80 percent of our problems are caused by a breakdown in systems" to "Design must understand and account for uncertainties and sensitivities." Interspersed within the presentations, the attendees will be provided the opportunity, in small groups, to develop lessons they have learned. Handouts will be provided of the presentations on these lessons learned.

This 2-day course will be offered on demand at MSFC.

System Safety Fundamentals – Level III
Program Overview: This course instructs the student in the fundamentals of system safety management and hazard analysis of hardware, software, and operations. Basic concepts and principles of the analytical process are stressed. The student is introduced to NASA publications that require and guide safety analysis, as well as to general reference texts on subject areas covered. Types and techniques of hazard analysis are addressed in enough detail to give the student a working knowledge of their uses and how they are accomplished. Skill in analytical techniques is developed through the use of practical exercises worked by the students in class. This course establishes a foundation for the student to pursue more advanced studies of system safety and hazard analysis techniques, while allowing students to effectively apply their skills to straightforward analytical assignments.

This 5-day course is offered on demand at MSFC.

Contracting Basics for Contracting Officer's Technical Representatives – Level III
Program Overview: The Contracting Officer's Technical Representatives (COTR) course provides instruction in the basic elements and features of a contract, the general process used to develop, award, and administer a contract, and the appropriate role of the COTR. Participants learn how to communicate effectively with both the contracting officer and the contractor as well as how to best perform advisory and monitoring responsibilities while serving as a COTR. The newly updated course material includes excerpts from the Federal Acquisition Regulations and any recent changes.

This 3-day course is offered several times each year at MSFC.

Advanced Systems Engineering and Integration – Level III
Program Overview: This course will provide a systematic, integrated, end-to-end view of a system from conceptual design and requirements definition through design and development, to development of mission operations concepts and ground infrastructure capabilities. A process-oriented approach is presented. The course will identify technical risks and discuss how to mitigate the risk in the most cost-effective manner, while maintaining the technical integrity of the system.

This course is currently under development by NET and will be offered at various Centers through the NET program. Currently there are courses offered by MSFC and NET that are acceptable substitutes until this course is available. These courses integrate lectures, videos, software, and group problem solving.

- Space Launch and Transportation Systems (SLaTS): A 5-day course that provides an integrated view of space launch and transportation system design. This course boils down the knowledge and wisdom that industry and government have in the SLaTS arena. This course is offered on demand at MSFC.
- Exploration Systems and Operations (EXPO) [formerly Human Exploration and Development of Space (HEDS)]: A 5-day course that provides a systematic, end-to-end view of most aspects of human spaceflight for Moon, Mars, and Earth-orbiting missions and systems. This course is offered at various Centers through the NET program.
- Science Mission and System Design and Operations (SMSDO): This 5-day course provides an integrated, end-to-end view of science mission and system design and operations for unmanned missions. This course is offered at various Centers through the NET program.

Sample Candidate Responses and Evaluations for a Level III Competency

Level III Competency	Candidate Response	Evaluation of Response
5.2 Project Monitoring and Control Leadership role in project tracking, reporting, and evaluation of technical performance metrics. Utilized earned value analysis, risk analysis, and technical reserve management. Leadership in developing, evaluating, and implementing mitigation efforts to address performance variances. Utilized continual technical monitoring and formal reviews.	Served as a review team member on various design reviews. Participated as the thermal lead for a project Technical Interchange Meeting that resulted in the resolution of a major cost and schedule issue.	**Not Acceptable** Candidate has not provided specifics to support leadership or management of this activity. Note that the response uses the term "served" and "participated;" for obtainment of Level III, candidates should demonstrate leadership and management responsibility in these skills.

Level III Competency	Candidate Response	Evaluation of Response
5.2 Project Monitoring and Control Leadership role in project tracking, reporting, and evaluation of technical performance metrics. Utilized earned value analysis, risk analysis, and technical reserve management. Leadership in developing, evaluating, and implementing mitigation efforts to address performance variances. Utilized continual technical monitoring and formal reviews.	Led a "tabletop" Critical Design Review for the OPGCA (protein crystal growth experiment) that flew on STS–88 in 1997. Established and allocated weight, power, and volume requirements to the various OPGCA components.	**Not Acceptable** Candidate has acquired the skill of leading a key design review, but has only demonstrated it on a small project, using a tailored review process. Technical metrics were established, but there was no mention of monitoring or control of these metrics. This is a weak response and only partially demonstrates having met this competency.

Level III Competency	Candidate Response	Evaluation of Response
5.2 Project Monitoring and Control Leadership role in project tracking, reporting, and evaluation of technical performance metrics. Utilized earned value analysis, risk analysis, and technical reserve management. Leadership in developing, evaluating, and implementing mitigation efforts to address performance variances. Utilized continual technical monitoring and formal reviews.	As the Environmental Control and Life Support Systems (ELCSS) Chief Engineer from 1997–1999, I led a Project Requirements Review (1998) and Preliminary Design Review (1999). I defined and quantified Review Item Dispositions (RID) issues and made presentations to the preboard and board. I signed RID closures along with the board chairman. I established 10 key, system-level technical performance metrics that were statused at each review. I broke these metrics into subsystem allocations and maintained a chief engineer's reserve. I led the evaluation of a number of technical risks so that their mitigation impacts could be included in the project schedule and budget prior to contract baselining. I reviewed the contractor's earned value variance reports and mitigation plans and reviewed the MSFC technical insight staffing at regular intervals to insure consistent staffing with project risks. All metrics were summarized and reported to the PM at monthly status meetings. The ECLSS project budget was in excess of $100 million.	**Acceptable** The candidate has demonstrated accountability and responsibility for multiple reviews. Specific project and dates are listed, and the candidate's role in various activities is included. Various project monitoring tools are mentioned and the associated leadership roles in the utilization of these metrics. ***Note: This is a critical competency, and while the candidate provided a strong response, the PMB may ask additional questions associated with this subject.***

Glossary

Acquisition: The acquiring, by contract, of supplies or services (including construction) through purchase or lease, whether the supplies or services are already in existence or must be created, developed, demonstrated, or evaluated. Acquisition begins at the point when Agency needs are established and includes the description of requirements to satisfy Agency needs, solicitation, and selection of sources, award of contracts, contract financing, performance, and administration, technical, and management functions directly related to the process of fulfilling Agency needs by contract.

Baseline: The technical performance and content, technology application, schedule milestones, and budget that are documented in the approved Program and Project Plans.

Configuration Management: A management discipline applied over the product's life cycle to provide visibility and to control performance and functional and physical characteristics.

Contract: A mutually binding legal relationship obligating the seller to furnish the supplies or services (including construction) and the buyer to pay for them. In addition to bilateral instruments, contracts include, but are not limited to, awards and notices of awards; job orders or task letters initiated under basic ordering agreements; letter contracts; orders, such as purchase orders, under which the contract becomes effective by written acceptance or performance; and bilateral contract modifications.

Earned Value Management: Earned Value Management (EVM) is a tool for measuring and assessing program/project performance through the integration of technical, cost, and schedule parameters during the execution of the program or project.

Formulation: The subprocess used to define the program/project concept and plan to meet customer requirements.

Functional Architecture: The arrangement of functions, their decomposition, and interfaces (internal and external) that defines the execution sequencing, conditions for control or data flow, and the relative performance levels of achievement for a desired outcome, or that provides a desired capability.

Implementation: The subprocess used to deliver the products and capabilities specified in the approved Program/Project Plan.

Infrastructure: The human resources, facilities, equipment, information resources, and administrative and program support services that are available to support programs and projects. Utilization of the capability afforded by the infrastructure includes consideration of the maintenance and other liabilities it presents.

Lesson Learned: The significant knowledge or understanding gained through past or current programs and projects that is documented and collected to benefit current and future programs and projects.

Life Cycle Cost: The total of the direct, indirect, recurring, nonrecurring, and other related expenses incurred, or estimated to be incurred, in the design, development, verification, production, operation, maintenance, support, and retirement of a system over its planned life.

Margin: The allowances carried in budget, projected schedules, and technical performance parameters (e.g., weight, power, or memory) to account for uncertainties and risks. Margins are baselined in the formulation subprocess, based on assessments of risks, and are consumed as the program/project proceeds through the life cycle.

Metric: A measurement taken over a period of time that communicates vital information about a process or activity. A metric should drive appropriate action.

Mission Assurance: Those independent activities performed outside of the program or project that are necessary to provide increased confidence in achieving mission success. The mission assurance activities will typically include independent assessments, Non-Advocate Reviews, process verification, program or project reviews and audits, quality assurance, software verification, and other activities that validate approaches and/or highlight potential problem areas.

Mission Success: Those activities performed in line and under the control of the program or project that are necessary to provide assurance that the program or project will achieve its objectives. Mission success activities will typically include risk assessments, system safety engineering, reliability analysis, quality assurance, electronic and mechanical parts control, software validation, failure reporting/resolution, and other activities that are normally part of a program or project work structure.

Mission: A major activity required to accomplish an Agency goal or to effectively pursue a scientific, technological, or engineering opportunity directly related to an Agency goal. Mission needs are independent of any particular system or technological solution.

Operational Architecture: Complete description of the system design, including the functional architecture allocated to the physical architecture, derived input/output, technology and system-wide, tradeoff, and qualification requirements for each component, an interface architecture that has been integrated as one of the components, and complete documentation of the design and major design decisions.

Physical Architecture: The hierarchical arrangement of product and process solutions, their functional and performance requirements, their internal and external functional and physical interfaces and requirements, and the physical constraints that form the basis of design requirements.

Program (Project) Team: All participants in program (project) formulation and implementation; this includes all direct reports and others that support meeting program (project) responsibilities.

Program Management Committee: One of the hierarchies of forums, composed of senior management, that assesses program and project planning and implementation and provides oversight and direction as appropriate. These are established at the Agency, Enterprise, Center, and lower levels.

Program: A major activity within an Enterprise having defined goals, objectives, requirements, and funding levels, and consisting of one or more projects.

Project Management Board: This board, which is co-chaired by the Manager of the Human Capital Office (HCO) and the Manager of SMO and consists of a number of deputy direct reports to the MSFC Center Director, evaluates candidates for certification award.

Project: An activity, designated by a program, characterized as having defined goals, objectives, requirements, a life cycle cost, a beginning, and an end.

Quality Assurance: A planned and systematic set of actions necessary to provide confidence that the products or services conform to documented requirements.

Reserves: The fiscal resources available for approved changes in program objectives or scope that are documented in the Program Commitment Agreement, the resolution of unforeseen major problems, program/project stretch-outs from Agency funding shortfalls and similar fiscal events, and the contingency resources including funding, schedule, performance, manpower, and services, allocated to and managed by the Program/Project Manager for the resolution of problems normally encountered to mitigate risks while ensuring compliance to the specified program/project scope.

Risk Management: An organized, systematic decision making process that efficiently identifies, analyzes, plans, tracks, controls, communicates, and documents risk to increase the likelihood of achieving program/project goals.

Risk: The combination of the following: 1) The probability (qualitative or quantitative) that a program or project will experience an undesired event such as cost overrun, schedule slippage, safety mishap, compromise of security, or failure to achieve a needed technological breakthrough; and 2) the consequences, impact, or severity of the undesired event, were it to occur.

Safety: Freedom from those conditions that can cause death, injury, occupational illness, damage to or loss of equipment or property, or damage to the environment.

Stakeholder: An individual or organization having an interest (or stake) in the outcome or deliverable of a program or project.

Success Criteria: That portion of the top-level requirements that define what will be achieved to successfully satisfy the Strategic Plan objectives addressed by the program, project, or technology demonstration.

System: The combination of elements that function together to produce the capability required to meet a need. The elements include all hardware, software, equipment, facilities, personnel, processes, and procedures needed for this purpose.

Systems Engineering: The process that involves the application of scientific and engineering efforts to accomplish the following: 1) Transform an operational need into a description of system performance parameters and a preferred system configuration through the use of an iterative process of functional analysis, synthesis, optimization, definition, design, test, and evaluation; 2) incorporate related technical parameters and ensure compatibility of all physical, functional, and program interfaces in a manner that optimizes the total system definition and design; and 3) integrate the efforts of all engineering disciplines and specialties into the total engineering effort.

Technical Insight/Penetration: The level of government involvement in contracted programs to mitigate program risk.

Technical Integration: The interactive activity among all participants in the design process, whereby the compartmentalized parts—subsystems (hardware and software), design functions, and discipline

functions—are designed and reintegrated into a balanced, successful total design. Technical integration is enabled by formal and informal information flow, by a system focus of all participants on how their part affects the total system, and by leadership that continually ensures that interactive aspects of the design are being addressed and balanced.

Verification: Proof of compliance with specifications. May be determined by a combination of test, analysis, demonstration, and inspection.

Work Breakdown Structure: A product-oriented hierarchical division of the hardware, software, services, and data required to produce the program's/project's end product(s), structured according to the way the work will be performed and reflective of the way in which program/project costs, schedule, technical, and risk data are to be accumulated, summarized, and reported.

Acronyms

APPL	Academy of Program/Project Leadership
CAIB	*Columbia* Accident Investigation Board
CoFR	Certificate of Flight Readiness
COTR	Contracting Officer's Technical Representative
CRM	Continuous Risk Management
DRD	Data requirement description
eCert	Electronic Certification
ECLSS	Environmental Control and Life Support Systems
EODD	Employee and Organization Development Department
EVM	Earned Value Management
EXPO	Exploration Systems and Operations
FPM	Foundations of Project management
HCO	Human Capital Office
HEDS	Human Exploration and Development of Space
IDP	Individual Development Plans
IT	Information technology
ITAR	International Traffic in Arms Regulations
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
NET	NASA Engineering Training
NORS	NASA Online Registration System
PM	Project Management
PMB	Project Management Board
PPA	Programs, projects, and activities
RID	Review Item Dispositions
SE	Systems Engineering
SEDP	Systems Engineering Development Process
SLaTS	Space Launch and Transportation Systems
SMO	Systems Management Office
SMSDO	Science Mission and System Design and Operation
VV&T	Verification, Validation, and Test
WBS	Work Breakdown Structure